

**What is claimed is:**

1           1. A process for forming a metal damascene structure,  
2 comprising the following steps:  
3           forming a dielectric layer on a substrate;  
4           etching the dielectric layer to form a damascene  
5           opening;  
6           providing a plasma treatment to remove remaining  
7           impurities on the dielectric layer; and  
8           filling a metal in the damascene opening.

1           2. The process as claimed in claim 1, wherein the  
2 plasma treatment uses a hydrogen-containing plasma, a  
3 nitrogen-containing plasma, an oxygen-containing plasma,  
4 or mixtures thereof.

1           3. The process as claimed in claim 2, wherein the  
2 hydrogen-containing plasma is hydrogen ( $H_2$ ) plasma or  
3 ammonia ( $NH_3$ ) plasma.

1           4. The process as claimed in claim 2, wherein the  
2 nitrogen-containing plasma is nitrogen ( $N_2$ ) plasma or  
3 ammonia ( $NH_3$ ) plasma.

1           5. The process as claimed in claim 2, wherein the  
2 oxygen-containing plasma is  $N_2O$  plasma or oxygen ( $O_2$ )  
3 plasma.

1           6. The process as claimed in claim 2, where the plasma  
2 treatment step uses  $H_2$  plasma,  $NH_3$  plasma,  $H_2/NH_3$  plasma,  
3 or  $H_2/N_2$  plasma.

1           7. The process as claimed in claim 1, wherein the  
2 damascene opening is a via.

1           8. The process as claimed in claim 7, wherein the  
2 damascene opening further comprises a trench above the  
3 via.

1           9. The process as claimed in claim 8, wherein the  
2 metal filling step includes filling copper or copper alloy  
3 in the trench and the via.

1           10. The process as claimed in claim 1, before the  
2 dielectric layer is formed, further comprising forming a  
3 first metal layer on the substrate.

1           11. The process as claimed in claim 10, wherein the  
2 first metal layer is copper or copper alloy.

1           12. The process as claimed in claim 11, wherein the  
2 plasma treatment is performed on the surface of the first  
3 metal layer.

1           13. The process as claimed in claim 12, wherein the  
2 plasma treatment removes remaining impurities on the  
3 first metal layer.

1           14. The process as claimed in claim 12, wherein the  
2 plasma treatment repairs the bonding between the first  
3 metal layer and the dielectric layer.

1           15. The process as claimed in claim 10, after the  
2 first metal layer is formed and before the dielectric

3 layer is formed, further comprising forming a cap layer  
4 on the first metal layer.

1 16. The process as claimed in claim 15, wherein the  
2 cap layer is nitride or silicon carbide.

1 17. The process as claimed in claim 15, wherein the  
2 plasma treatment repairs the bonding between the first  
3 metal layer and the cap layer.

1 18. A process for forming a metal damascene  
2 structure, comprising the following steps:  
3 forming a cap layer on a first metal layer;  
4 forming a dielectric layer on the cap layer;  
5 etching the dielectric layer with  
6 fluorine-containing plasma or  
7 chlorine-containing plasma to form a damascene  
8 opening;  
9 plasma treating using a hydrogen-containing plasma;  
10 and  
11 filling a metal in the damascene opening.

1 19. The process as claimed in claim 18, wherein the  
2 hydrogen-containing plasma is hydrogen ( $H_2$ ) plasma or  
3 ammonia ( $NH_3$ ) plasma.

1 20. The process as claimed in claim 18, wherein the  
2 plasma treatment step uses  $H_2$  plasma,  $NH_3$  plasma,  $H_2/NH_3$   
3 plasma, or  $H_2/N_2$  plasma.

1 21. The process as claimed in claim 18, wherein the  
2 damascene opening is a via.

1           22. The process as claimed in claim 21, wherein the  
2           damascene opening further comprises a trench above the  
3           via.

1           23. The process as claimed in claim 22, wherein the  
2           metal filling step includes filling copper or copper alloy  
3           in the trench and the via.

1           24. The process as claimed in claim 18, wherein the  
2           first metal layer is copper or copper alloy.

1           25. The process as claimed in claim 18, wherein the  
2           cap layer is nitride or silicon carbide.

1           26. A process for forming a metal damascene  
2           structure, comprising the following steps:  
3           forming a cap layer on a first metal layer, wherein  
4           the cap layer is a nitride layer;  
5           forming a dielectric layer on the cap layer;  
6           etching the dielectric layer to form a damascene  
7           opening;  
8           plasma treating using a nitrogen-containing plasma;  
9           and  
10          filling a metal in the damascene opening.

1           27. The process as claimed in claim 26, wherein the  
2           etching step uses fluorine-containing plasma or  
3           chlorine-containing plasma.

1           28. The process as claimed in claim 26, wherein the  
2           nitrogen-containing plasma is nitrogen (N<sub>2</sub>) plasma.

1           29. The process as claimed in claim 26, wherein the  
2 plasma treatment step uses  $\text{NH}_3$  plasma,  $\text{N}_2$  plasma,  $\text{H}_2/\text{NH}_3$   
3 plasma, or  $\text{H}_2/\text{N}_2$  plasma.

1           30. The process as claimed in claim 26, wherein the  
2 damascene opening is a via.

1           31. The process as claimed in claim 30, wherein the  
2 damascene opening further comprises a trench above the  
3 via.

1           32. The process as claimed in claim 31, wherein the  
2 metal filling step includes filling copper or copper alloy  
3 in the trench and the via.

1           33. The process as claimed in claim 26, wherein the  
2 first metal layer is copper or copper alloy.

1           34. A process for forming a metal damascene  
2 structure, comprising the following steps:  
3           forming a cap layer on a first metal layer;  
4           forming a dielectric layer on the cap layer;  
5           forming a photoresist pattern on the dielectric  
6           layer, wherein the photoresist pattern  
7           contains carbon;  
8           etching the dielectric layer using the photoresist  
9           pattern as a mask to form a damascene opening;  
10          plasma treating using an oxygen-containing plasma;  
11          and  
12          filling a metal in the damascene opening.

1           35. The process as claimed in claim 34, wherein the  
2 etching step uses fluorine-containing plasma or  
3 chlorine-containing plasma.

1           36. The process as claimed in claim 34, wherein the  
2 oxygen-containing plasma is N<sub>2</sub>O plasma or oxygen (O<sub>2</sub>)  
3 plasma.

1           37. The process as claimed in claim 34, wherein the  
2 damascene opening is a via.

1           38. The process as claimed in claim 37, wherein the  
2 damascene opening further comprises a trench above the  
3 via.

1           39. The process as claimed in claim 38, wherein the  
2 metal filling step includes filling copper or copper alloy  
3 in the trench and the via.

1           40. The process as claimed in claim 34, wherein the  
2 cap layer is nitride or silicon carbide.